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ABSTRACT

In an attempt to individualize an automotive course, the Vocational-Technical Division of Northern Montana College has developed Occupational Sequences for an engine rebuilding course. Occupational Sequences, a learning or teaching aid, is an analysis of numbered operations involved in engine rebuilding. Job sheets, included in the book, provide a procedure which should be employed to complete a particular segment of engine overhaul. The individualized job sheet is not necessarily a complete job, but is a breakpoint where a student may need additional assistance or direction. Operation sheets, which are included, are written and sequenced to provide a student with a logical procedure for job completion. Related information sheets, also contained in the document, offer information that is useful or needed to complete an operation. They are keyed to the operation in the Occupational Sequences chart. All the materials in the book may be duplicated. (Author/AJ)

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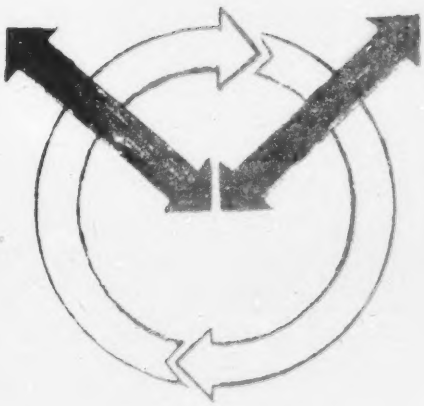
AUTO ENGINES I
AT 121

OCCUPATIONAL SEQUENCES



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INTRODUCTION

Occupational sequences consist of Job Sheets, Operation Sheets, and Related Information.

The Job Sheets, found in the front of the book, are a procedure to complete a segment of an engine overhaul (example- valve related work or valve job).

Operation Sheets, found in the middle of the book and numbered 1-22, are a breakdown of the various jobs. Listed in sequence, the Operation Sheets give a step-by-step procedure for each operation.

Related Information Sheets are lettered A-Z and are found in the last half of the book. They contain information that is useful or needed to complete an operation.

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OCCUPATIONAL SEQUENCE CHART

Title of Unit:
AUTO ENGINES I AT 121

Field:
AUTO TECH

OPERATIONS

1 Disassemble Engine
2 Clean & check rocker arm assem.
3 Disassemble Head
4 Inspect and measure valves
5 Inspect and test valve springs
6 Assemble head
7 Remove block accessories
8 Disassemble block
9 Inspect, clean, & measure block
10 Clean and measure pistons
11 Inspect and measure rods
12 Measure camshaft
13 Install crankshaft
14 Install camshaft & timing gears
15 Install piston rings
16 Check and install piston & rod assemblies
17 Install block accessories
18 Assemble engine
19 Time engine
20 Time & test run engine

JOBS	1	2	3	4	5	6																									
Disassemble & valve related	1	2	3	4	5	6																									
Related Information	A B O D E	A B O P e	A B O F		L N S	D R D P																									
Disassemble & component msm.							1 A C	2 A O E M	3 F G I N R	4 A O F A	5 F G I L M	6 A E S	7 A E S T																		
Short block assembly														1 B M L D N Y	2 A O O S K	3 A O I X	4 O W N V Y	5 A C F J V													
Complete eng. assem. & test																			1 A C J Y	2 A B O N Y	3 A O Z	4 A C Z									
Related Information																															

ITEMS OF RELATED INFORMATION

A Service manuals
B Cleaning fluids
C Engine types
D Parts layout
E Gaskets
F Micrometer
G Telescoping gauge
H Small hole gauge
I Straightedge
J Thickness gauge
K Cut of round and taper
L Over and under sizing
M Valve seat angles
N Valve springs
O Pre lubricants
P Valve seals
Q Cylinder ridge
R Deglazing hone
S Dial indicator
T Valve lash and valve lift
U Mthd. of measuring bearing clrn
V Torque wrench
W Rod alignment fixture
X Piston rings
Y Ring compressors
Z Timing engine

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AUTO ENGINES I AT 121

Job 1 Disassembly and Valve Related

Includes Operations 1-6

Materials: Engine mounted on stand

General description of the job:

The valve related parts of the engine will be removed and tested for reuse.

Procedure:

1. Operation 1 Disassemble engine
2. Operation 2 Clean and check rocker arm assemblies
3. Operation 3 Disassemble head
4. Operation 4 Inspect and measure valves
5. Operation 5 Inspect and measure valve spring
6. Operation 6 Assemble head

AUTO ENGINES I AT 121

Job 2 Disassembly and Component Measurement

Includes Operations 7-13

Materials: Engine mounted on stand, V-blocks

General description of the job:

The job consists of disassembling the short block, to include inspection and measurement of component parts.

Procedure:

1. Operation 7 Remove block accessories
2. Operation 8 Disassemble block
3. Operation 9 Inspect, clean, and measure block
4. Operation 10 Clean and measure pistons
5. Operation 11 Inspect and measure rods
6. Operation 12 Inspect and measure crankshaft
7. Operation 13 Measure crankshaft

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Job 3 Short Block Assembly

Includes Operations 14-18

Materials: Engine stand
V-blocks

General description of the job:

The job consists of assembling and measuring clearances of various components of the short block.

Procedure:

1. Operation 14	Install crankshaft
2. Operation 15	Install camshaft and timing gears
3. Operation 16	Install piston rings
4. Operation 17	Install piston and rod assemblies
5. Operation 18	Check and install oil pump

AUTO ENGINES I AT 121

Job 4 — Complete Engine Assembly and Test Run

Includes Operations 19-22

Materials: Engine mounted on stand
Heat exchanger

General description of the job:

The job consists of installing short block components and engine accessories, as well as timing and test running the engine.

Procedure:

1. Operation 19 — Install block accessories
2. Operation 20 — Assemble engine
3. Operation 21 — Time engine
4. Operation 22 — Time and test run engine

Operation 1 — Disassemble engine

Tools and materials needed:
student tool kit

Related information:
A, B, C, D, and E

Operation breakdown:

Steps	Key points
1. Remove intake manifold	a. Some V8 engines require the removal of the distributor, before intake manifold can be removed.
2. Remove exhaust manifold	a. Two manifolds are used on a V-type engine.
3. Remove rocker arm cover	a. Two covers used on V-type engines.
4. Remove rocker arm assemblies and push rods	a. Two assemblies required on V-type engines. b. Keep push rods in proper order. c. Note length of push rod. d. Note assembled position (up & down). e. On over head cam engine the camshaft will be removed at this time. f. Some engines use a ball & rocker thus eliminating the need of a rocker arm shaft.
5. Remove heads	a. Note length of head bolts and location of different length bolts. b. Note position of head gasket.
6. Clean parts	

Safety:
None

Questions:
1. What is the difference between an intake manifold and an exhaust manifold?
2. Why are we concerned about the length of the head bolts and their location?

Operation 2 .. Clean and check rocker arm assemblies

Tools and materials needed:
student tool kit
micrometer
telescopeing gauge

Related information:
A, B, D, F, and G

Operation breakdown:

Steps	Key points
1. Remove rocker arms from shaft	a. When disassembling an engine using rocker and ball assemblies, keep the rocker arm and ball in matched sets. b. On rocker arm shaft assemblies note the assembly order of the rocker arms. c. Note position of rocker arms.
2. Clean parts	
3. Visually check for cracks and breakage	
4. Check obvious wear patterns	a. Note scoring and galling.
5. Measure shaft and rocker arm bore	a. The rocker and ball cannot be measured for wear.
6. Assemble rocker arm to shaft	a. Some rocker arms have replaceable bushings, thus only the bushing need be replaced. b. Assemble rocker arm shafts, with oil holes in the downard position.

Safety:
None

Questions:
1. Why is it important to install the rocker arm shaft with the oil holes down?
2. How are the rocker and ball type rocker arms lubricated?

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Operation 3 Disassemble head

Tools needed:
student tool kit
spring compressor
small bore gauge
micrometer
straightedge
thickness gauge

Related information:
A, B, D, F, H, I, J, K and L

Operation Breakdown:

Steps	Key points
1. Compress valve spring and remove retainers spring and valve seal	a. Before attempting to remove valve, remove burrs from valve stem to prevent damage to the valve guide.
2. Clean head	a. If water passages in head are plugged or filled with sludge, it will be necessary to use a hot emulsion-solvent cleaner.
3. Check head for warpage	a. If warpage exceeds mfg. Spec. resurface head.
4. Measure valve guide bore for taper and out of round	a. Measure at the top, center, and bottom of guide, also at right angles to find maximum wear points. b. Record readings.
5. Inspect valve seat	a. If the seat is below the surface of the combustion chamber, a new seat may be required.

Safety:
Use caution when compressing valve springs, an injury may result if the compressor slips and releases a valve keeper.

Questions:
1. Why is it important to check cylinder head for warpage?
2. When measuring valve guides, why are we concerned about the maximum wear point?
3. What will result if the burrs are not removed from the valve stem?

Operation 4 — Inspect and measure valves

Tools and materials needed:
student tool kit
micrometer
small bore gauge

Related information:
D, F, G, K, and M

Operation Breakdown:

Steps	Key points
1. Visually inspect valve for warpage, cracking, and burned condition	a. Discard if these conditions are found.
2. Measure valve margin	a. Discard if less than 3/64 in.
3. Measure stem with micrometer ¼ in. below machine surface of valve head end	a. Measure at two points, the second point at a right angle to the first. b. If more than .001" under sized, discard valve. c. Record measurements.
4. Measure the stem at the center of the valve travel	a. As in 3a above. b. As in 3b above. c. Record measurements.
5. Measure at the lower end of the valve stem ¼ in. from the keeper's groove	a. Same as in 3a above. b. As in 3b above. c. Record measurements.
6. Calculate valve stem clearance, using information obtained in Operation 3	a. Example: Guide dia. .374 Valve dia. .372 Valvestem Clearance .002 b. Not to exceed .002 clearance.

Safety:
None

Questions:
1. Why is the valve margin critical?
2. Where on the stem does most of the wear occur?
3. What can be done if the stem to guide clearance is excessive?

Operation 5 — Inspect and test valve springs

Tools and materials needed:
6 inch steel ruler
valve spring tester
steel square

Related information:
D, N, and O

Operation Breakdown:

Steps	Key points
1. Check springs for squareness	a. Use a steel square to see if both ends are parallel. b. If more than 1/16 inch out of square, discard the spring.
2. Measure free length	a. Discard spring if they do not meet mfg. spec.
3. Test valve spring for compression at specified length.	a. Refer to mfg. spec. b. Discard if the springs aren't within 10% of the rest of the springs. c. Two checks may be required (open and close).

Safety:
None

Questions:
1. What three checks are made on valve springs?
2. What is the importance of checking valve spring tension?
3. What would be the result of a cocked valve spring?

Operation 6 — Assemble head

Tools and materials needed:
spring compressor
prussion blue

Related information:
D, N, O, and P

Steps	Key points
1. Check seating contact area	a. Valve should seat in center 1/3 of the valve face. b. Seat should be 3/64 to 3/32 inch in width. c. Check mfg. spec. for proper seat width.
2. Install valve in respective position	a. Lube valve stem.
3. Install seals	a. Umbrella seals fit over stem and seat on valve guide. b. O ring seals are installed at this time, after valve spring is compressed.
4. Install springs, retainers, and keepers	a. Install closed coiled end of spring, toward head.

Safety:
Use caution when compressing valve spring, as injury may result if the compression slips and releases a valve keeper.

Questions:
1. Why is the location of contact seating area important?
2. Why is the width of the seat important?
3. When are the O ring type seals installed?

Operation 7 Remove block accessories

Tools and materials needed:
student took kit
vibration dampener puller

Related information:
A and D

Operation Breakdown:

Steps	Key points
1. Remove vibration dampener	
2. Remove water pump and timing cover	a. Note position of oil slinger.
3. Remove timing gears and chain if equipped.	a. Note timing mark alignment on timing gears. b. Not all engines have a timing chain.
4. Remove lifters	a. Store parts so same relative position is retained.
5. Remove bell housing, starter, fly wheel	a. Note number and position of crankshaft dowel pins if so equipped.
6. Rotate engine in test stand and remove oil pan	a. Drain oil prior to rotating engine.
7. Remove oil pump	a. Note installation of oil pump drive shaft.

Safety:
Lock test stand in position after rotating.

Questions:
1. Why are timing marks located prior to removal of timing chains and gears?
2. Why are lifters stored to retain the same position?

Operation 8 — Disassemble block

Tools and materials needed:
ridge reamer
student took kit

Related information:
A, D, B, Q, and R

Operation Breakdown:

Steps	Key points
1. Rotate engine on stand and remove cylinder ridge	a. Remove a minimum amount of material as excessive material removal may destroy the cylinder.
2. Remove pistons	a. Number rods and caps. b. Mark bearings, using masking tape. (example) #1 cap #1 rod c. Note assembly marking on piston and rod.
3. Remove crankshaft	a. Number main bearings. b. Mark bearings using masking tape. (example) #1 block #1 cap c. Note assembly marking on main caps. d. Note location of main thrust bearing. e. Store crankshaft in a vertical position.
4. Remove camshaft	a. Note how camshaft is retained in block. b. Note how timing gears are lubricated. c. Store camshaft in vertical position.

Safety:
Keep working area free of oil spills.

Questions:
1. Why are bearings numbered to retain the same relative position?
2. Why are the camshaft and crankshaft stored in a vertical position?
3. What would happen if rods were not numbered?

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Operation 9 — Inspect, clean, and measure block

Tools and materials needed:
student tool kit
micrometer
telescopic gauge
straightedge
feeler blades

Related information:
E, F, G, I, J, K, L, and M

Operation Breakdown:

Steps	Key points
1. Clean block	a. If water passages are plugged or filled with sludge or if block has heavy grease deposits, it will be necessary to use a hot emulsion solvent cleaner.
2. Visually inspect block	a. Check for cracks, breaks or flaws in block - magniflux technique.
3. Measure cylinder out of round	a. Measure in the upper ring travel where the most wear occurs. b. Record measurements. c. Take several measurements to find maximum wear point.
4. Measure cylinder taper	a. Measure at the lower end of the cylinder to determine taper and the standard bore or oversize. b. Record measurements.
5. Check for warpage of block at head and block mating surface	a. If exceeds mfg. spec. resurface the block.
6. Check main bearing saddle bore for warpage	a. If exceeds mfg. spec. will be necessary to align bore saddle bores.
7. Measure main bearing saddel bore for taper and out of round	a. Record measurements. b. If exceeds mfg. spec. will be necessary to align bore saddle bores.
8. Measure cam bearings for wear, out of round, and taper	a. Record measurements. b. If wear exceeds mfg. spec., it will be necessary to replace cam bearings.
9. Hone cylinders	a. Adjust speed of drill and up and down movement of the bore to obtain a 60 degree cross hatch pattern. b. Thoroughly clean cylinders to

Operation 9 continued

Safety:
None

Questions:
1. Why are we concerned about the taper and out of round of a cylinder?
2. What effect would a warped block have on a crankshaft?
3. What is the purpose of a 60 degree cross hatch pattern in a cylinder?
4. What would be the effect of abrasive left in a cylinder?

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Operation 10 — Clean and measure pistons

Tools and materials needed:
- student tool kit
- ring expander
- ring groove cleaner
- micrometer
- telescoping gauge

Related information:
A, D, F, G, K, and L

Operation Breakdown:

Steps	Key points
1. Remove rings	a. Note type and positions of rings b. Remove rings starting from the top.
2. Clean piston head and piston grooves	a. Use carbon scraper to clean piston head. b. Use ring groove cleaner to clean ring grooves (do not use a wire brush).
3. Remove rod from piston	a. Note assembly marks, there is a left and right to the rod and a front and a rear to the piston.
4. Check ring groove wear	a. Use a new ring to check "clearance," should not exceed .006. b. If clearance exceeds .006, the groove must be machined and a spacer installed.
5. Measure piston size	a. Make measurement at the lower end of piston skirt at right angles to pin boss. b. Record measurements. c. Calculate clearance using information obtained in operation 9, steps 3 and 4. example: cylinder dia. 3.785 piston dia. 3.780 clearance 0.005 d. If clearance exceeds mfg. spec., piston must be replaced or resized.
6. Measure piston pin bore, oversized, out of round taper	a. Record measurements.
7. Measure piston pin	a. Record measurements. b. Calculate pin clearance of piston. example pin bore .985 pin .984 clearance .001

Operation 10 continued

c. If clearance exceeds mfg. spec. an oversized pin must be installed.

Safety:
None

Questions:
1. Why are pistons measured at the skirt?
2. What would be the effect of excessive side clearance of the ring?
3. What determines the rear and front of a piston?

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Operation 11 — Inspect and measure rods

Tools and materials needed:
- student tool kit
- connecting rod aligning fixture
- micrometer
- telescoping gauge

Related information:
A, F, G K, L, V, and W

Operation Breakdown:

Steps	Key points
1. Measure pin bore of rod	a. Record measurements. b. Calculate pin clearance of rod, using information obtained in step 7, operation 10. example pin bore .985 pin dia. .984 clearance .001 c. If clearance exceeds mfg. spec., an oversize pin must be installed.
2. Inspect bearing seating surface	a. Must be free from nicks and scores.
3. Measure bearing bore of rod	a. Measure for out of round and oversize.
4. Check for twist or bend	a. Clamp rod securely in fixture. b. A bend and twist condition may be present in the same rod.
5. Check for double bend	a. Use a flat surface and compare height of pins end of rod on both sides. b. Straighten to achieve an equal height on both sides.

Safety:
None

Questions:
1. Of what importance is the finish on the bearing seating surfaces?
2. How would one check an off set-rod for double bend?
3. Would a bend in a rod affect the length of the rod?

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Operation 12 — Inspect and Measure Crankshaft

Tools and materials needed:
micrometer

Related information:
A, F, and S

Operation Breakdown:

Steps	Key points
1. Check for run out of crankshaft	a. Mount crank on V block mount dial indicator on center and slowly rotate, reading will show amount of run out or warpage. b. Should not exceed .002.
2. Measure for undersized shaft on rods and mains	a. Record measurement. b. Crankshaft ground .010, .020, .030, .040 under mfg. spec. c. Should not exceed mfg. spec.
3. Measure out of round	a. Record measurements. b. Should not exceed mfg. spec.
4. Measure taper	a. Record measurements. b. Should not exceed mfg. spec.

Safety:
None

Questions:
1. What is the importance of checking crankshaft run out?
2. Why are crankshafts not ground down more than .040?
3. Can out of round and taper exist on the same crank journal?

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Operation 13 — Measure camshaft

Tools and materials needed:
micrometer
dial indicator

Related information:
A, F, S, and T

Operation Breakdown:

Steps	Key points
1. Measure bearing journals for out of round and taper	a. Discard camshaft if exceeds mfg. spec.
2. Measure cam lift	a. Measure head to toe and base circle, subtract base circle measurement from heel-toe measurement to obtain cam lift. example heel-toe .298 base circle .124 lift .174 b. Discard if exceeds mfg. spec.
3. Check camshaft for run out	a. Place cam in V blocks, mount dial indicator on center bearing.

Safety:
None

Questions:
1. What is the function of the gear that is an integral part of the camshaft?
2. On an I head engine, is the cam lift and valve lift equal?
3. In comparison to the crankshaft, what is the speed ratio of the camshaft?

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Operation 14 Install crankshaft

Tools and materials needed:
student tool kit
torque wrench
plasti-gauge
lubriplate

Related information:
A, D, K, L, O U, and V

Operation Breakdown:

Steps	Key points
1. Place upper halves of main bearing in block	a. Note oil passage alignment. b. Note lubrication of thrust main bearing.
2. Install crank in saddle bores	
3. Place plasti-gauge on main journals	a. Plasti-gauge should be the same length as bearing width.
4. Install lower bearing halves in main caps, install on block and torque to mfg. spec.	a. Note numbering of main bearing caps. b. Torque main bearing bolts in a series of steps.
5. Remove caps and check clearance	a. Record clearance. b. If clearance exceeds mfg. spec. and undersized bearing should be installed. c. Record clearance.
6. Remove crankshaft, and lubricate main bearings, install rear main seal, reinstall crankshaft, and torque main bearings	a. Torque main bearing cap in steps as per mfg. spec. b. Check for free rotation of crankshaft.
7. Check end play of crankshaft	a. End play will be affected by the alignment of the main bearing thrust cap.

Safety:
None

Questions:
1. Why is the bearing clearance checked prior to prelubrication of the mains?
2. What controls the end play on the crankshaft?
3. What type of seal is used for the rear main bearing?

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Operation 15 Install camshaft and timing gears

Tools and materials needed:
student tool kit
torque wrench

Related information:
A, D, O, S, and V

Operation Breakdown:

Steps	Key points
1. Install camshaft	a. Lube journals prior to installation. b. Check for free rotation.
2. Install camshaft retainer and timing gears	a. Torque retainer bolts, prior to installing timing gear. b. Position crankshaft and camshaft to align timing marks as noted in operation 7, step 3.
3. Check camshaft end play	a. Record end play reading.

Safety:
None

Questions:
1. How is camshaft and end play adjusted?
2. What would happen if camshaft was forced too far into the block?
3. What would be the effect if timing gear marks were not correctly aligned?

Operation 16 — Install piston rings

Tools and materials needed:
student tool kit
ring expander
feeler blade

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Related information:
A, D, J. and)

Operation breakdown:

Steps	Key points
1. Check ring ga	a. Record measurement. b. Check mfg. spec. c. Back ring requires different gap.
2. Install rings and pistons	a. Install lower ring first. b. Install all rings on pistons prior to assembly to block. c. Inside grooves on piston rings are assembled in upward position, outside grooves in downward position.
3. Adjust ring gap location	a. Position rings so the gaps are not in alignment.

Safety:
None

Questions:
1. What would happen if ring gap was insufficient?, excessive?
2. What would happen if ring gaps were in alignment?

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Operation 17 Install piston and rod assemblies

Tools and materials needed:
student tool kit
ring compressor
oil # 30
plasti-gauge
lubriplate

Related information:
A, D, J, U, V, X, and Y

Oporation breakdown:

Steps	Key points
1. Install pistons	a. Lubricate piston rings and cylinder with oil. b. Tighten ring compressor sufficiently to compressor rings. c. Note numbering of position and rod assembly.
2. Install rod cap	a. Place plasti-gauge on rod journal. b. Note position and direction of oil squirt holes on rod. c. Torque rod bearing bolt as per mfg. spec.
3. Remove rod cap and check clearance	a. Record clearance.
4. Lubricate bearing and reinstall cap	a. Torque rod bearing bolt as per mfg. spec.
5. Rotate crank shaft to check for free rotation	a. If a bind occurs, disassemble and check for cause.
6. Repeat steps 1, 2, 3, 4, and 5 on remaining piston and rod assembly	a. Refer to key points in steps 1, 2, 3, 4, and 5.

Safety:
None

Questions:
1. Of what importance is the oil squirt holes in the rods?
2. Why is the crankshaft rotated after installing each piston?
3. After installing the piston in the cylinder how could one determine if a rod was bent?

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Operation 18 — Check and install oil pump

Tools and materials needed:
student tool kit
feeler blades
plasti-gauge

Related information:
A, D, F, I, J, and V

Operation Breakdown:

Steps	Key points
1. Visual inspection of pump gears and body	a. Check for scoring.
2. Check for warpage of pump cover	a. Discard if exceeds mfg. spec.
3. Check side clearance of gears and/or rotor	a. Discard if exceeds mfg. spec.
4. Check end clearance	a. Check dry with plasti-gauge. b. Check clearance under specified torque.
5. Valve operation of oil relief	a. Check tension and length of relief valve spring in the same manner as a valve spring.
6. Install pump	a. Note position of drive shaft. b. Some engines require timing of oil pump.

Safety:
None

Questions:
1. Why must some oil pumps be timed?
2. Of what importance is the clearance of the oil pump?
3. What is the function of the relief valve?

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Operation 19 Install block accessories

Tools and materials needed:
student tool kit
torque wrench

Related information:
A, D, O, and V

Operation Breakdown:

Steps	Key points
1. Install front timing cover and water pump	a. Replace seal in cover prior to installation. b. Install oil slinger as noted in operation 7, step 2. c. Lip off seal installed to inside.
2. Install vibration dampener	a. Torque dampener bolt as per mfg. spec.
3. Install oil pan	a. Note height of oil pick up screen.
4. Install flywheel bell housing and starter	a. Install flywheel in same position as it was in at the time you removed it.
5. Rotate engine in test stand and replace lifters	a. Lub lifters before installation. b. Install lifters in same location as when removed.

Safety:
None

Questions:
1. Of what significance is the height of the oil pick up screen?
2. What is the function of the vibration dampener?
3. What is the function of the flywheel?

Operation 20 — Assemble engine

Tools and materials needed:
student tool kit
torque wrench

Related information:
A, D, O, J, T, and V

Operation Breakdown:

Steps	Key points
1. Install head	a. Install head gaskets as noted in operation 1, step 5.
2. Install push rods, rocker arm assembly	a. Install related parts in the order and position noted in operation 1, steps 1, 2, 3, 4, and 5. b. In an overhead cam engine the camshaft will be installed at this time. c. Some engines require valve adjustment.
3. Install intake manifold and fuel system	a. On some engines the intake must be installed prior to installing rocker arm assembly and push rods.
4. Install exhaust manifold and rocker arm covers	a. On V-type engines, note left and right rocker arm covers.
5. Adjust valve lash	a. On some engines adjustment is not required.

Safety:
None

Questions:
1. Are exhaust manifold gaskets used on all engines?
2. What is the purpose of the exhaust passage in the intake manifold?

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Operation 21

Related Information:
A, D, and Z

Operation breakdown:

Steps

1. Install distributor

Key points

a. If engine crankshaft was not rotated since timing gear installation, #1 piston should be at TDC.

b. Check mfgr. spec. for position of rotor and location of #1 cylinder.

c. Check mfgr. for correct firing order.

Safety:
None

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Operation 22 — Time and test run engine

Tools and materials needed:
student tool kit
timing light

Related information:
A, D, and Z

Operation Breakdown:

Steps	Key points
1. Fill fuel tank	a. Crank engine until fuel reaches carb.
2. Check electrical system	a. As points open, sparks should occur at center electrode of coil.
3. Start engine	a. Note engine R.P.M. Do not over speed. b. Note oil pressure, should have pressure in the first 30 seconds of running.
4. Adjust idle	
5. Time engine	a. Time engine as per mfg. spec. b. Time at idle with vacuum lines off.
6. Run engine, adjust valves, and idle air fuel mixture	a. Note water temperature. b. Valve adjusted at low idle. c. Note loud noises. d. Note for oil and water leaks.
7. Check out with instructor	

Safety:
Do not allow gasoline to contact electrical system.

Questions:
Oral

AUTO ENGINES I AT 121

Information A Service Manuals

Essential Facts, Ideas, and Procedures

The service manuals are designed for the service person's use, and contain all the necessary information to properly diagnose and repair any part of an automobile.

The service manuals available to you, the student, are: Motor's Auto Repair Manual, National Service Data, and Chilton Auto Repair Manuals. Chilton's manuals and Motor's manuals, published each year, contain information on all makes of domestic automobiles for the previous five years. National Service Data is published each year and contains information on all makes of automobiles for that year only.

Chilton's and National manuals are about the same physical size, so one can see that the National Service Data will contain more information, as it only covers models of one year.

Also available to you, the student, is the Manufacturer's Service Manual which covers only one make and one year automobile. If one has a choice, the Manufacturer's Service Manual contains by far the most information.

The service manuals are provided by the school for your use and convenience. Make use of them.

Questions:

1. If a motors manual contains only a certain amount of information, of what value is it?

Information B Cleaning fluids

Definition: Cleaning fluids are used to remove the accumulation of greases, oil and baked-on deposits from normal engine use.

Essential Facts, Ideas, and Procedures

As no one cleaning method will remove all types of engine accumulations, a number of cleaning methods are available. The cleaning fluids available to you, the student, are: a cold solvent, steam cleaner, hot emulsion cleaner, and cold emersion carbon solvent cleaner. The steam cleaner produces a high pressure spray which melts grease and oil and carries them away. By mixing a soap or detergent with the steam, the steam cleaner becomes more eificient.

The steam cleaner creates a great deal of vapor and therefore must be used outside or in a well ventilated area.

The cold solvent is used with manual brushing action to remove mild accumulations of grease and oil but will not remove carbon. To remove the baked-on accumulation of dust, grease, and residue left in water jackets, a hot emulsion cleaner is used. The parts are placed in a tank containing a strong detergent and agitator. After cleaning in the hot tank, the parts are removed and rinsed with hot water. Oil must be applied to the machine portions to prevent rust.

The detergents used in the hot tank are corrosive to aluminum and bearing materials, so all bearings and aluminum parts must be removed before placing in the hot tank.

To remove varnish from small aluminum parts, such as carburators and lifters, a cold emersion carbon solvent cleaner is used and requires from one to two hours to clean. The parts are then rinsed with hot water and air dried.

Questions:

1. What type of cleaner should be used to clean large aluminum parts?
2. What type of cleaner should be used to clean a cast iron block?

References:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 37-42).

Stocker, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 9-1 - 9-9)

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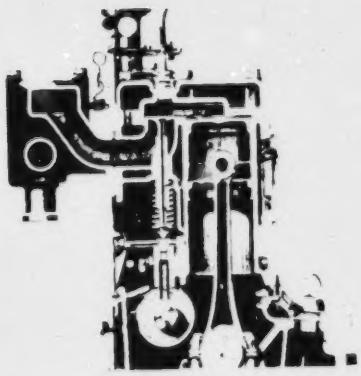
Information C — Engine types

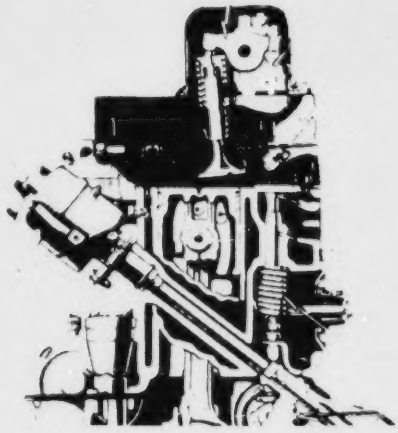
Definition: The type of engine refers to the location of the valves.

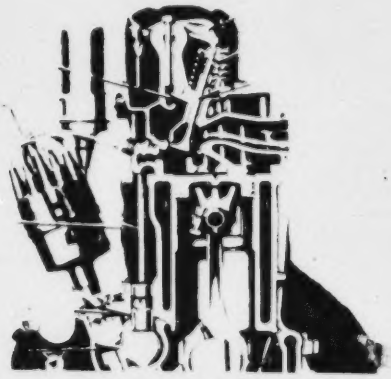
Essential Facts, Ideas, and Procedures

Location of the valves determines the type of the engine - in an I head the valves are located in the head of the engine, in an L head the valves are located in the block. The F head contains one valve in the block and one valve in the head on the same side of the cylinder. Another design is the overhead camshaft, where the camshaft and valve are located in the head. By drawing a line parallel with the piston and a line from the piston to the valve head we would have the shape of the letter that the engine is named after. As basic engine types we have basic block types: in-line block, V-type block, and opposed or "flat" block. Each type block can have the various valve locations shown below.

BASIC ENGINE TYPES:

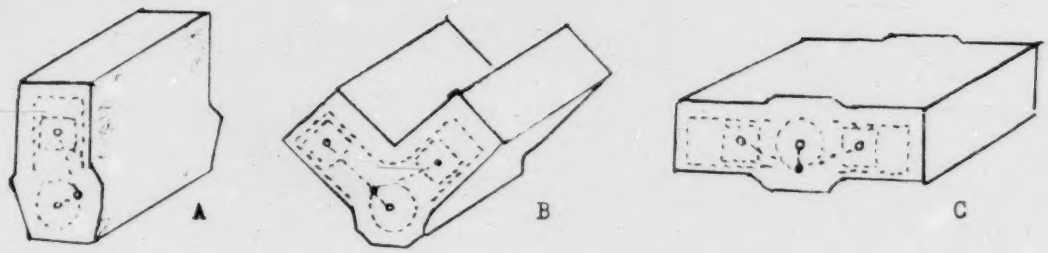






Information C continued

BASIC BLOCK TYPES



Types of cylinder blocks. (A) In-line block, (B) V-type block, (C) Opposed or "flat" block.

Questions:

1. Can there be an overhead valve type engine?
2. What is a common name for the L head engine?

References:

Tabalt, William K., Motors Service Automotive Encyclopedia. Homewood, Ill.: Goodheart-Willcox Co., 1965. (pp 4-5 - 4-7).

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 43-74).

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Information D Parts layout

Definition: Parts layout is a numbering system or an order in which parts are temporarily placed so that they can be reinstalled in the same relative position.

Essential Facts, Ideas, and Procedures

When disassembling an engine all parts should be stored or numbered so that the parts can be reinstalled correctly. Another important reason is that wear patterns on component parts give useful clues to the cause of the engine failure. A good example is that a diagonal wear pattern on a piston indicates a bent rod. If the rod was separated from the piston and was not numbered much time would be expended in locating the one bent rod.

Many of the parts of an engine are selective fit, that is, each part is machined to its mating part. An example is a piston that is machined to a tolerance of +.0005. If the cylinder is also machined to +.0005 it is possible to have .001 excessive clearance or no clearance at all.

The wear pattern also plays a very important part, as wear patterns differ from one identical part to another. We would have a poor contact surface if the parts were mismatched.

Questions:

1. Would pushrod contact surface be affected by changing relative locations?
2. Give an example for numbering pushrods.

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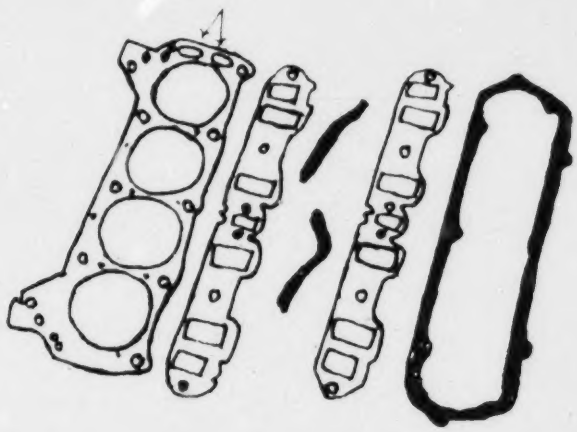
Information E Gaskets

Definition: Gaskets are to provide a sealing action between two matching surfaces.

Essential Facts, Ideas, and Procedures

Gaskets provide a seal between two matching surfaces. A gasket can be used with or without a gasket cement. Usually the cement is used to hold the gasket in place during assembly. In the event that the gasket cement is used, use it sparingly!

Head gaskets are of prime importance. If they are not installed correctly they may cause overheating, oil and water leaks, and failure to seal the combustion chamber and water jackets. The head gasket meters and controls the flow of the coolant. Head gaskets are usually marked to indicate position. If they are not marked, the larger holes for coolant circulation are installed to the rear of the engine. These larger coolant passages ensure coolant circulation through the head.



Questions:

1. On a V-type engine is there any difference between the left and right head gasket?
2. True or false: Some engines have oil passages in the head gasket.

Reference:

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 4-1 - 4-8).

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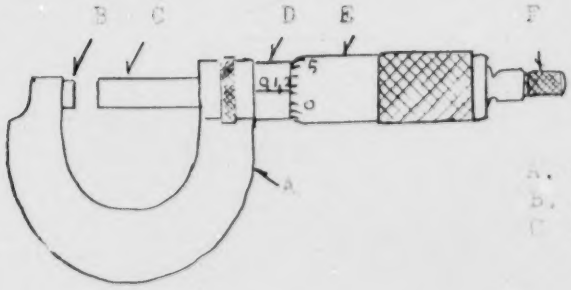
Information F — Micrometer

Definition: The micrometer is an instrument for measuring accurately in degrees of .0001 of an inch.

Essential Facts, Ideas, and Procedures

The micrometer is designed to measure the outside diameter of cylindrical forms and also the thickness of materials. On the outside micrometer the spindle C is attached to the thimble E, on the inside, at the point of adjustment which is often provided with a ratchet stop F. The part of the spindle which is concealed within the sleeve and thimble is threaded to fit a nut in the frame A. The frame being stationary, the thimble E is revolved by the thumb and finger, and the spindle C, being attached to the thimble, revolves with it and moves through the nut in the frame, approaching or receding from the anvil B.



A. Frame
B. Anvil
C. Spindle
D. Sleeve
E. Thimble
F. Ratchet stop

The measurement of the opening between the anvil and the thimble is indicated by the line and figures on the sleeve D and the thimble E.

The pitch of the screw threads on the concealed part of the spindle is 40 to an inch. One complete revolution of the spindle, therefore, moves it longitudinally 1/40th or .025 of an inch. The sleeve D is marked with 40 lines to the inch, corresponding to the number of threads on the spindle. When the micrometer is closed, the bevelled end of the spindle coincides with the line marked 0 on the sleeve, and the 0 mark on the thimble also coincides with the horizontal line on the sleeve.

Opening the micrometer by revolving the thimble one revolution will make the 1 line of the thimble coincide with the horizontal line of the

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Information F continued

sleeve. The distance between anvil B and spindle C is therefore .025 of an inch. The bevelled edge of the thimble from one of these divisions to the next moves the spindle longitudinally 1/25 or .025, or .001 of an inch.

To read the micrometer, multiply the number of vertical divisions visual on the thimble by 25 and add the number of divisions on the bevel of the thimble from 0 to the line which coincides with the horizontal line on the sleeve.

Questions:

1. When the thimble of a micrometer is turned one division as indicated by the lines on the bevelled edge of the thimble, how far has the spindle moved?
2. Why must the spindle not be turned down too tightly?

References:

McMackin, Frank J., The Mathematics of the Shops. Princeton: D. Van Nostrand Company, Inc., 1947. (pp 57-59)

Billau, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 490-493)

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Information G

Telescoping Gauge

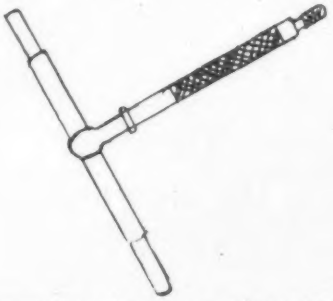
Definition: The telescoping gauge is used to measure inside diameter with .001 or greater accuracy.

Essential Facts, Ideas, and Procedures

Inspect and clean the surface of the part to be measured. Select the proper size telescoping gauge for the job.

NOTE: Telescoping gauges are available in a variety of sizes with telescoping heads which will measure openings of $\frac{1}{2}$ inch up to 6 inches.

Compress the telescoping head and lock it in the compressed position by turning the knurled screw in the handle. Place the telescoping head in the hole to be measured.



Release the telescoping head or plunger by loosening the screw in the end of the handle to allow the gauge ends to come into contact with the surface of the part to be measured. Lock the plunger with knurled screw and rock the handle to check the setting. The gauge should lightly contact both sides of the cylinder at the greatest diameter. Several settings may be necessary to get an accurate measurement. Remove the gauge from the hole carefully. Place a micrometer over the contact ends of the gauge and read the size on the micrometer.

Questions:

1. Why must the edges of the telescoping gauge contact both sides of the cylinder?
2. Why must the measurement be checked more than once?

References:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (p 30).

Tabalt, William K., Motors Service Automotive Encyclopedia. Homewood, Ill.: Goodheart-Willcox Co., 1965. (p 3-2).

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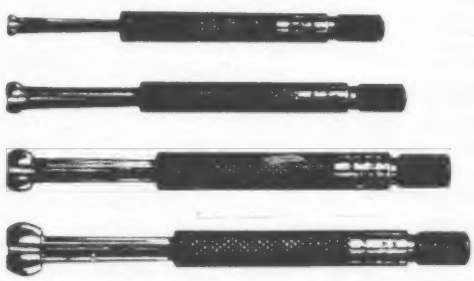
Information H — Small hole gauges

Definition: The small hole gauge is used to measure an inside diameter with .001 or greater accuracy.

Essential Facts, Ideas, and Procedures

Inspect and clean the surface of the part to be measured, select the proper gauge for the job. NOTE: small bore gauges are available in sizes to cover a range from .125 to .500 of an inch.



The contact surface of the gauges consists of a split steel ball that is adjusted by turning the knurled knob located at the end of the handle. The sides of the split ball should lightly contact both sides of the hole being measured.

The size is obtained by measurement with an outside micrometer.

Questions:

1. What is the difference between a telescoping gauge and a small bore gauge?
2. Is it possible to use an inside micrometer to measure a bore of .500 of an inch or less?

References:

LS Starrlett Company, "Starrlett Tools." Athal, Mass., 1965. (p 115).

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 2-5 - 2-6).

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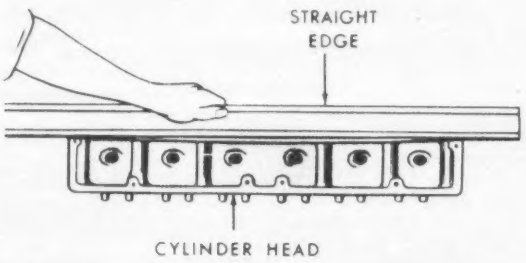
AUTO ENGINES I AT 121

Information I Straightedge

Definition: The straightedge is a tool that is used for testing for a warped or bent condition on a flat surface.

Essential Facts, Ideas, and Procedures

The straightedge is designed to test for a warped condition on a flat surface. Place the straightedge on the flat surface being tested and check for clearance under the straightedge. The amount of clearance can be determined by inserting a feeler gauge blade under the straightedge.



When checking for a warped condition a minimum of two checks should be made, the second at right angles to the first.

Questions:

1. Why are two checks made?
2. What causes warpage?

Reference:

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (p 16-1).

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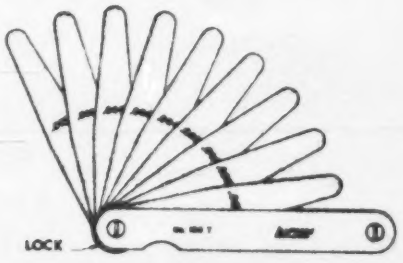
Information J — Thickness gauges

Definition: A thickness gauge is used to measure clearance smaller than .125.

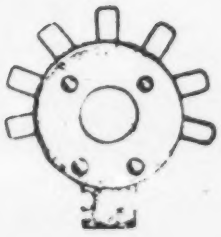
Essential Facts, Ideas, and Procedures

A thickness gauge, commonly called a feeler blade, is a series of blades that are ½ inch in width and vary in thickness. The blades can be used individually or in combination. The clearances are measured by selecting a blade or a number of blades that will pass between the surfaces.

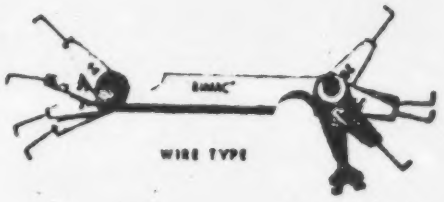
Thickness gauges can also be a number of wires varying in thickness. Wire gauges must be used individually.



BLADE TYPE



WIRE TYPE



WIRE TYPE

Questions:

1. What is a wire type gauge used for?
2. Where would a blade type thickness gauge be used?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 31-32).

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Information K — Out of round and taper

Definition: Out of round and taper are wear conditions resulting from uneven pressures.

Essential Facts, Ideas, and Procedures

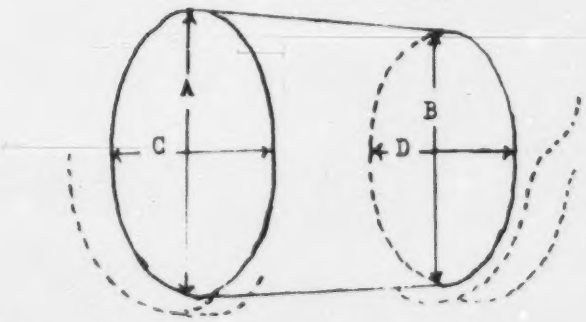
Out of round and taper can be in a cylinder bore as well as in a cylinder shaft. Taper is a wear condition in which the diameter of one end of a shaft is smaller or larger than the other end.

Out of round is a wear condition on a cylinder bore or cylinder shaft where the shaft or bore is egg shaped. To determine taper, measure at one location then again at right angles to the first measurement. The difference between the two diameters is out of round.

A taper or out of round condition can occur at any point on a bore or shaft but will be located where the most pressure is exerted.

A vs B = Vertical taper
C vs D = Horizontal taper
A vs C and B vs D = out-of-round

Check for out-of-round
at each end of journal



CRANKSHAFT JOURNAL

Information K continued

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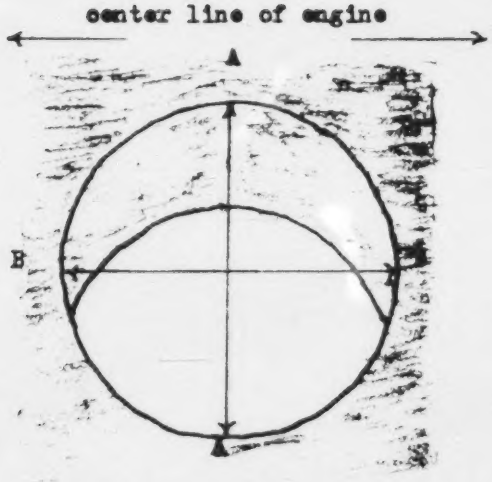

A. At right angle to center line of engine

B. Parallel to center line of engine.

1. Out-of-round = difference between A and B.

2. Taper = difference between A measurement at top of cylinder bore and the A measurement at bottom of cylinder bore.

Questions:

1. Why are we concerned with taper and out of round conditions?

2. What tools would be needed to measure taper in a valve guide?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 80, 82, 95, 100-102, 151, 154, 200).

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Information I. Over and under sizing

Definition: When a component part is worn beyond use, the part is remachined to a standard undersized or oversized and reused.

Essential Facts, Ideas, and Procedures

Parts that are worn beyond mfg. spec. are machined and placed back in service. An example is a crankshaft that is worn beyond mfg. spec. Rather than discard the shaft, it is turned down from .010" to .040", making it undersized, and a bearing of the proper undersize is installed. An undersized bearing is thicker to compensate for the material removed from the shaft. Contrary to what many mechanics believe, the thickness of the bearing material, or babbit, on the new bearing is the same as the old bearing, however the steel backing is thicker.

When a cylinder is excessively worn the cylinder is bored to a standard oversize of .020", .030", or .060" and the piston and the rings are machined to the corresponding size.

Valve guides and wrist pins can also be oversized when wear warrants their replacement. The main reason for machining vs replacement of parts is a cost factor as well as a savings of time due to the availability of parts.

Questions:

1. Define the differences between oversize and undersize.
2. What are the potential problems when re-finding a crankshaft down more than .040"?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 95, 104-106, 157-160, 216).

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Information: Valve seat angles

Definition: Valve seat angles are the angles at which the valves are ground to ensure the best sealing action and provide the longest life.

Essential facts, ideas, and Procedures

The valves on most automobiles are mfg. with a face angle of 30 or 45 degrees. This angle provides the best sealing action and longer life. A valve face angle of 60 degrees or greater would provide better sealing or wedging action but would be relatively short in life.

If the valve face and valve seat are the same angle (45 degrees), there would be a wide contact or seating area (see diagram A) allowing good heat dissipation (a heat transfer from the valve to the valve seat and into the surrounding coolant). However, a small amount of carbon on the valve seat or valve face could hold the valve open. Thus it is necessary to reduce the width of the valve seat. This is done by grinding a recess in the valve seat at 15 degrees and 75 degrees (see diagram b). If the width of the seat was reduced excessively there would be poor heat dissipation resulting in premature valve failure due to burned valves. Thus the valve seat width is critical.

To further ensure a carbon cutting action as well as a good initial sealing action, the valve is ground to an interference angle of 44 degrees (see diagram C).

After the valve seats, this interference angle will be eliminated, with the valve seat conforming to the shape of the valve face, still retaining the width of the valve seat.

When checking the location of valve seating with bluing it is important to remember that the complete contact area will not be shown, only the upper edge of the contact area. By knowing the width of the seat, we will be able to determine if the seating area is in the center of the valve face. Note that it is important not to reverse the interference angles.

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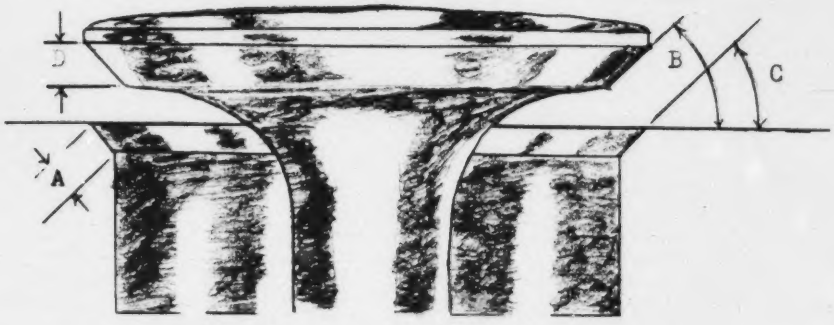
Information M continued



A. Seat Width
B. Face Angle = 45 degrees
C. Seat Angle = 45 degrees
D. Contact Surface

FIGURE A

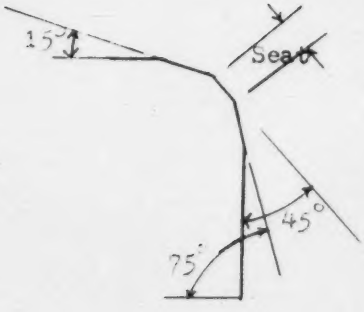


FIGURE B

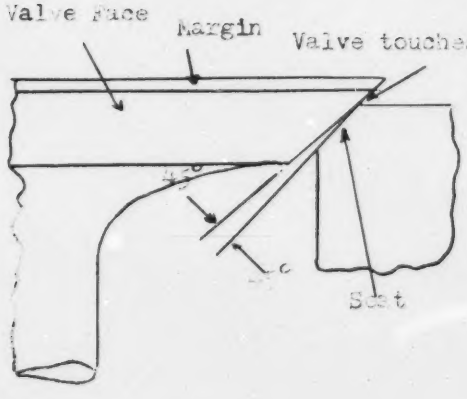


FIGURE C

On automobiles equipped with hard valve seat inserts or stellite valves, the valve interference angles are not used. The wear resistence is greater on these valves and if the very narrow contact area was retained it would result in poor heat dissipation.

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Information M continued

Questions:

1. What would happen if the interference angles were reversed?
2. At what angle must the valve face be to obtain an interference angle if the seat is 30?

Reference:

Billiet, Walter E., Automobile Engines Maintenance and Repair, Chicago: American Technical Society, 1973. (pp 169-224).

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Information N Valve springs

Definition: The function of a valve spring is to close the valve at all operating speeds.

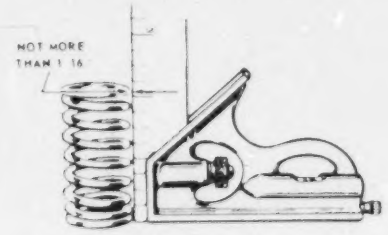
Essential Facts, Ideas, and Procedures

The valve spring serves to close the valve without any strain on the valve train. If the valve spring is too strong, it will apply excessive pressure on the camshaft, lifter, pushrod, and rocker arm, resulting in premature wear. Conversly, if the spring is too weak there will not be adequate time for closing the valve, resulting in a pounding action on the valve train and a missfire in the cylinder.

The direction in which the spring exerts the pressure is also important. A spring that is cocked or bent more than 1/16 of an inch can cause excessive side pressure on the valve stem, thereby causing valve stem wear and miss alignment of the valve seat.

Another check made on the spring is the installed height. Change of the spring-installed height is not due to a spring malfunction, but rather to the removal of metal on the valve seat and valve during normal valve reconditioning service, causing the valve to extend deeper into the head.

Valve springs are tested for proper pressure by compressing the spring to a recommended distance and recording the pressure. If the spring fails to register within 10 pounds of recommended pressure the spring should be replaced.



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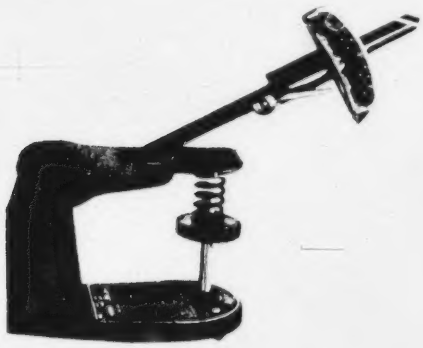
Information N continued

The valve springs are checked for a cocked or bent condition by testing with a steel square. Stand the spring on end on a flat surface, move the square up to the spring, rotate the spring and note a space, if any, between spring and square on upper end of spring.



Questions:

1. List three checks made on a valve spring.
2. How would you correct valve spring-installed height?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 204-5).

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Information C

Prelubricants

Definition: A prelubricant is a lubricant that is placed on all moving parts during assembly as a means of reducing wear until the engine oiling system builds up pressure and volume.

Essential Facts, Ideas, and Procedures

After an engine overhaul it may take several minutes for the oil to reach many of the moving parts. In this time permanent damage may result. For this reason a prelubricant is installed on all moving parts. Oil can be used but its acility to stay in place is limited.

Most automotive supply stores stock and sell an oil or grease designed for this purpose.

Questions:

1. What would happen if a prelubricant was not used?
2. What would happen if oil was used as a prelubricant, and the engine set for a period of time before starting?

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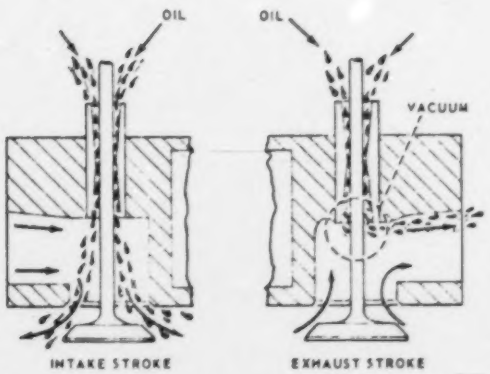
Information P — Valve seals

Definition: Valve stem seals are for the prevention of oil loss through the valve guide.

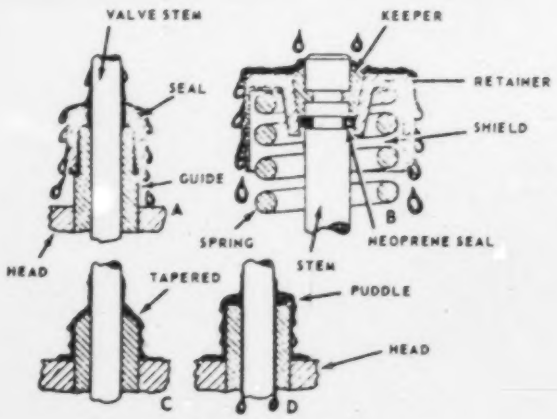
Essential Facts, Ideas, and Procedures

There are three types of basic oil seals. The ring type is installed in a groove below the keeper groove, sealing between the spring retainer and valve stem. This type seal prevents oil that is collected at the top of the spring retainer from following the valve stem down to the guide where the oil is picked up by engine vacuum and forced into the combustion chamber.

The second type is the umbrella type which rides on the valve stem and protrudes over the valve guide to prevent oil from entering the combustion chamber.



Both intake and exhaust guides will pass oil.



Devices used to prevent oil consumption through the guides. A-Guide seal. B-Neoprene seal and shield. C-Tapered guide top. Note how the square cut guide in D allows oil to puddle and run through the guide.

The last type is a positive seal which is force fit on the guide and the stem glides through the seal. This seal is by far the best seal for controlling oil leakage. However, in many cases the seal does prevent adequate entrance of proper lubrication of the guide and valve stem.

Information F continued

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Questions:

1. On the O ring type valve seal, what prevents oil from entering under the seal?
2. On the umbrella seal, does the seal move with the valve stem?

Reference:

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (p 13-13).

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Information Q Cylinder ridge

Definition: A cylinder ridge is the unworn section of a cylinder beyond the upper limits of ring travel.

Essential Facts, Ideas, and Procedures

Cylinder ridge is the result of wear caused by ring contact with the cylinder walls. It is important that this ridge be removed prior to the removal of the piston and rod assembly to prevent damage to the ring lands. (see figure A)

If a cylinder ridge is not removed and new rings are installed on the piston breakage of the new rings and piston lands will result because the new rings are thicker and have a square shoulder and will extend farther up into the cylinder.

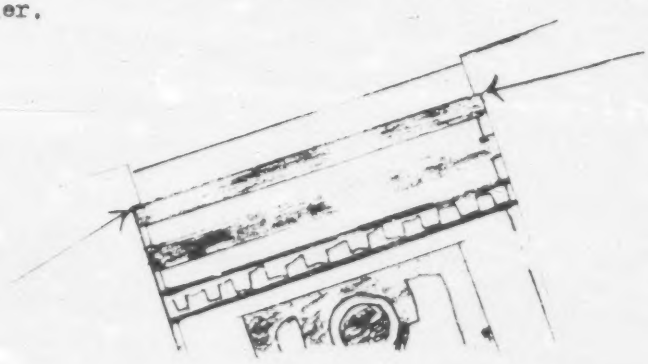

Figure A

To remove the cylinder ridge a ridge remover is used. The ridge remover is adjustable to fit most cylinder sizes and contains a cutter to effectively remove the ridge. When removing the ridge it is important not to remove an excessive amount of material, as excessive material will effect the rings ability to control oil consumption. (see figure B)

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Information Q continued

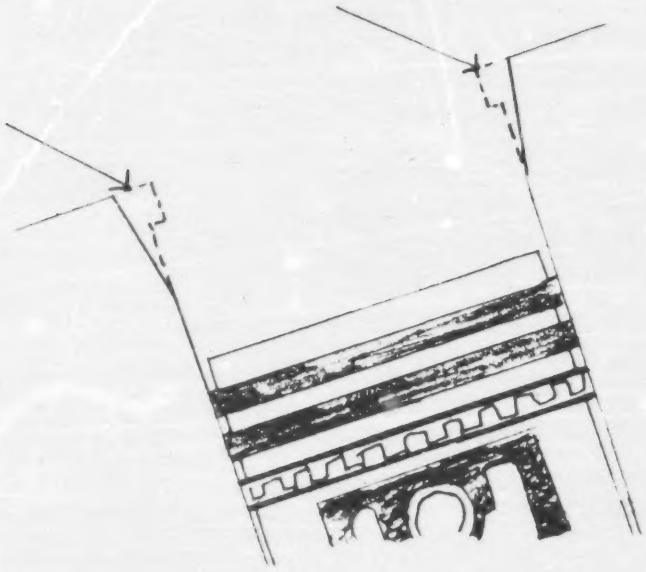

Figure B

Questions:

1. Does the cylinder ridge equal cylinder taper?
2. How could the piston and rod assembly be removed without removing the cylinder ridge?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 103-104).

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Information R Deglazing hone

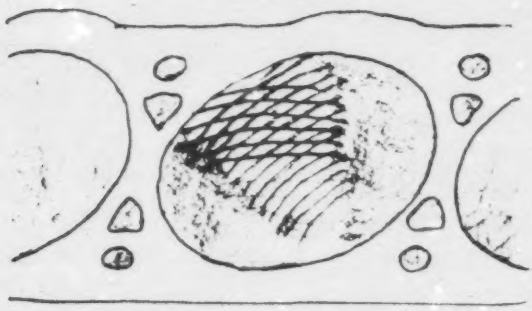
Definition: A deglazing hone is used to remove the glazing on a cylinder wall during an engine overall.

Essential Facts, Ideas, and Procedures

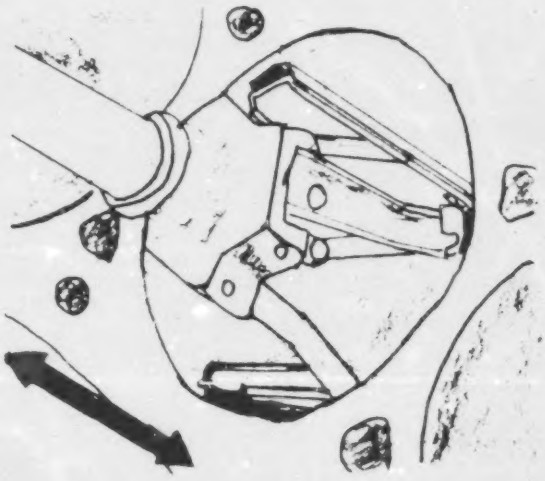
In the course of engine operation a glaze develops on the cylinder walls. When new rings are installed it is not possible for the rings to seat on the hard glazed surface. For this reason the glaze must be removed.

Deglazing is accomplished through the use of a hone. The hone is expandable to accomodate different size cylinders. Honing should be done by moving the hone up and down at the proper rate to get a cross hatch pattern. The most satisfactory cross hatch pattern is when the hone marks intersect at a 60 degree angle. This cross hatch pattern facilitates effective ring sealing.

NOTE: After honing it is important to clean the cylinders with soap and water to remove the metal filings and abrasives.



Correct Pattern



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Information H continued

Questions:

1. What would happen if the abrasives were not removed from the block?
2. Could a hone be used effectively to remove a cylinder ridge?

Reference:

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 166-167).

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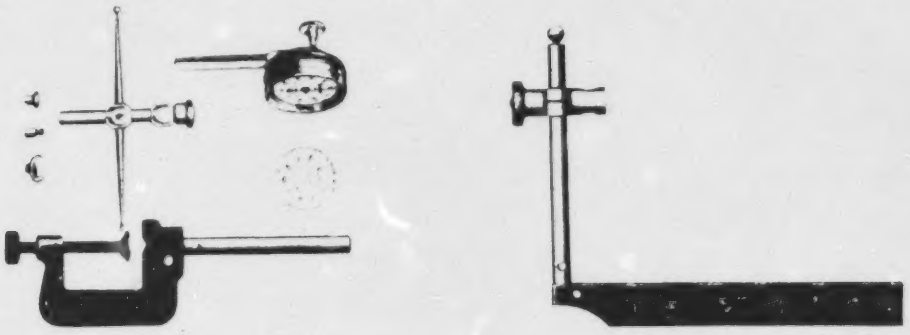
Information S , Dial Indicator

Definition: A dial indicator is a gauge that gives a direct recording in thousands of inch, of clearances a backlash.

Essential Facts, Ideas, and Procedures

A dial indicator is used for checking endplay and runout. When checking endplay on a crankshaft or camshaft the dial indicator base is mounted on the block and the contact point of the dial indicator touching the shaft. With the dial zeroed, move the shaft from one extreme to the other, the endplay will be indicated by the movement of the needle.

Runout on a shaft can be checked by mounting the shaft on V-blocks and mounting the dial indicator on a pedestal base, the contact point touching the shaft and shaft rotated.



Questions:

1. What is the importance of checking runout?
2. What is the importance of checking endplay?

Reference:

Tillict, Walter E., Automobile Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (p 108).

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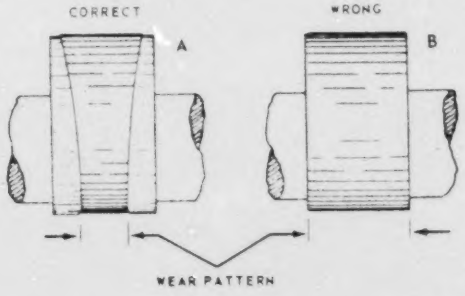
Information T — Valve lash and valve lift

Definitions: Valve lash is the total clearance of the valve train. Valve lift is the total movement of the valve from the open to the closed position.

Essential Facts, Ideas, and Procedures

Valve lift is the total distance the valve moves and is determined by the cam lift and the ratio of the rocker arm. To determine the cam lift, measure the base circle and then measure the distance from the heel to the nose, subtract base circle from heel-toe measurement.

As the cam lift is reduced by wear, a wider contact area or wear pattern can be noticed on the cam and the bottom side of the lifter. Many times a visual inspection of the cam will eliminate the need to measure cam lift.



Usual cam lobe wear pattern. A-Correct. B-Wrong.

Valve lift is determined by the cam lift plus the increased lift due to the rocker arm ratio. Example:

valve lift	.098
rocker arm ratio - 1 to 1.5 =	.049
valve lift	.147

Valve lash is measured with a thickness gauge. When piston is on T.D.C. compression stroke, the measurement is made between the rocker arm and the valve stem. The valve lash can be adjusted while the engine is running at slow idle.

When hydraulic lifters are used, there is zero lash or the lash is taken up by the action of the lifter. On some engines the valve lash is adjusted when the engine is disassembled by grinding material off the end of the valve stem. On other types of engines there is an adjustment on the rocker arm. For adjustment procedures refer to a service manual.

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Information T continued

Questions:

1. Will valve lash effect valve lift?
2. Will valve lash effect valve timing?

References:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 183-184).

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 13-27, 13-35 - 13 37, 15-11).

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AUTO ENGINES I AT 121

Information U — Methods of measuring bearing clearances

Definition: Bearing clearance is the space allowed between the bearing and the shaft for heat expansion and oil film.

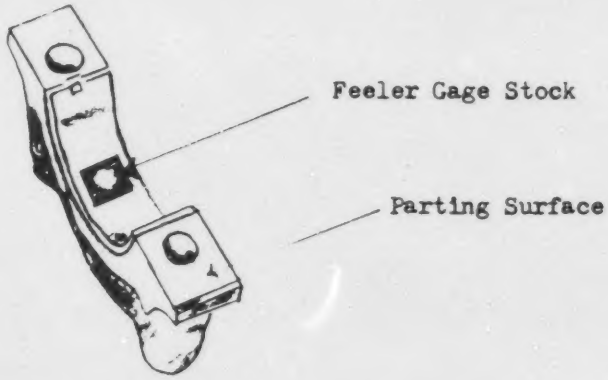
Essential Facts, Ideas, and Procedures

There are three universally accepted practices of checking oil clearances. The first method is an actual measurement of the shaft size subtracted from the inside diameter of the bearing. Example:

shaft size	2.725
bearing I.D.	2.724
clearance	0.001

Another method utilizes $\frac{1}{2}$ inch squares shim stock placed between the bearing and the shaft. If shim of .001 of an inch thickness is placed between shaft and bearing and a slight resistance felt while rotating the shaft, there would be about .001 of an inch of clearance. If no drag was felt while rotating the shaft another shim of .002 of an inch would be installed and rechecked.

NOTE: It is important that the bearing and the shaft be lubricated with oil while making this oil clearance check. The shim stock must be removed prior to final assembly.



The last method, using plasti-gauge, is the most widely used. To check clearances with plasti-gauge, a short section of the wire shaped plastic is placed between the bearing and the shaft, with the bearing cap bolts torqued to the proper specs.

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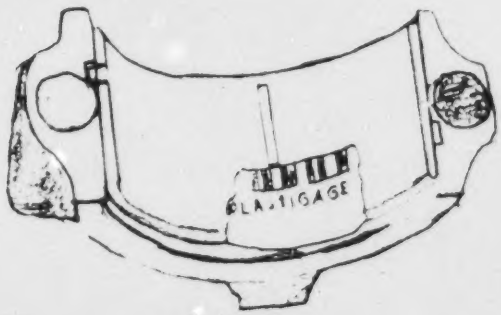
Information U continued

Clearances are determined by removing the cap and bearing and comparing the width of the flattened plasti-gauge to a scale that is printed on the plasti-gauge container. The wider the plasti-gauge becomes the less the clearance. Conversly, the narrower the plasti-gauge the more the clearance.

NOTE: It is important that the bearing and shaft be at room temperature, no oil present, and the shaft not rotated when the plasti-gauge checks are made.



Questions:

1. Of the different methods of checking oil clearance, what method do you think is most accurate?
2. Why is the plasti-gauge used without oil?

Reference:

Billiet, Walter E., Automobile Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 112, 153-154).

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Information V Torque wrench

Definition: The torque wrench measures the twisting force that is applied to a bolt.

Essential Facts, Ideas, and Procedures

By exerting pressure to a steel beam which is solidly attached to an object at the other end and examining the relationship between pull at the end of the beam and the amount of bend in the beam, one can determine the amount of torque. A one foot steel beam will bend a predetermined amount (readable on a scale) if a socket is attached at one end and ten pounds of pressure is exerted at the other end. The ten pounds of force exerted on the steel beam would equal ten foot pounds of torque.

Torque wrenches can be calibrated in inch pounds as well. Example: The ten pounds of force exerted to the beam one foot long would equal 120 inch pounds. To convert foot pounds to inch pounds, multiply the foot pounds by 12; to convert inch pounds to foot pounds divide inch pounds by 12.

The range of a torque wrench can be increased by adding an adapter to increase the length of the wrench. If the wrench is calibrated to 0-100 foot pounds of torque and 180 pounds of torque is required for a specific job, the wrench may be used by adding an adapter equal to the length of the torque wrench. The torque readings are then multiplied by two. A 90 foot pound reading would equal the 190 foot pounds of torque required for the job.

Make sure the bolts are clean and lubricated when torquing bolts and follow the mfg. spec. for torque and sequence.

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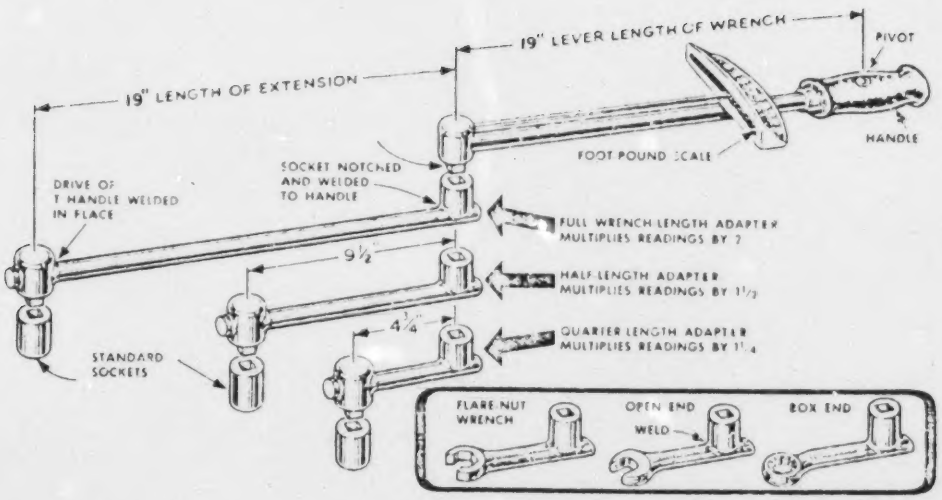
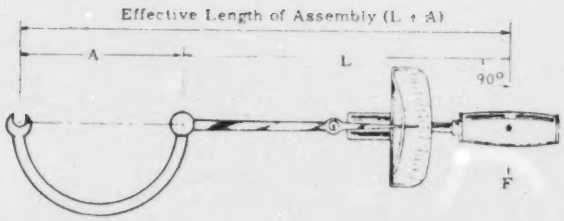
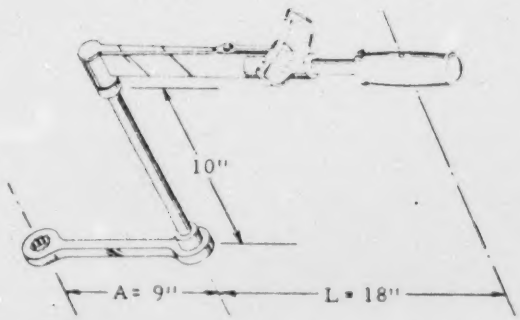
Information V continued







Questions:

1. A wrench 19 inches long, with an extension of 4 3/4 inches would increase the reading by ?
2. Why must the bolt be cleaned and lubricated?

Reference:

Stockel, Martin W., Auto Service and Repair. Homewood, Ill.: Goodheart-Willcox Co., 1969. (pp 3-13 - 3-18).

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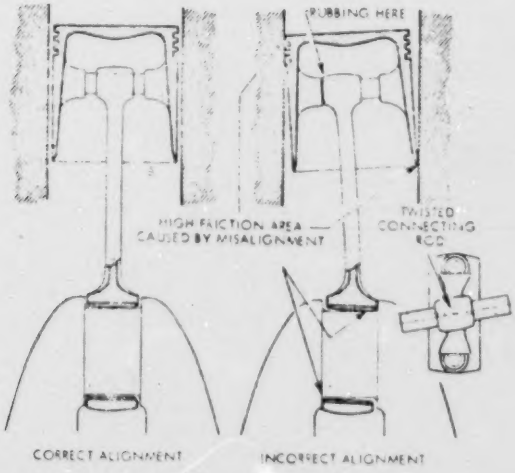
Information W

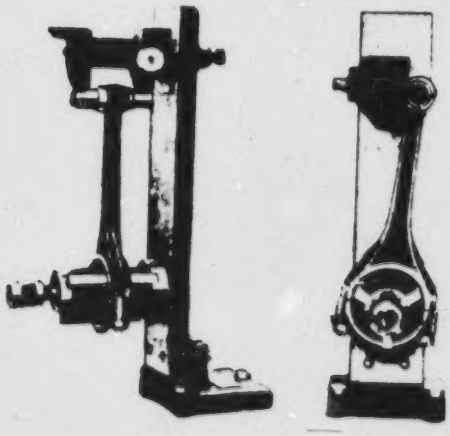
Rod alignment fixture

Definition: A rod alignment fixture is used for checking for correcting a bent or twisted rod.

Essential Facts, Ideas, and Procedures

When checking rod alignment the rod is clamped to the arbor of the fixture. The amount of twist can be checked against the side of the aligner. If either condition is present the rod can be straightened on the fixture by bending with an adjustable wrench.





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AUTO ENGINES I AT 121

Information A Piston rings

Definition: Piston rings are installed to control compression blow by and control oil comsumption.

Essential Facts, Ideas, and Procedures

There are two kinds of rings, compression rings and oil rings. On an automobile engine three rings are usually used - two compression rings and one ring for oil control. Rings are manufactured in various designs to improve the efficiency of oil and compression control. Thus the installation procedures are quite critical.

When installing rings it is important that the rings gap is not in alignment when installed on the piston; it is installed at right angles to the thrust surface of the piston. Most ring manufacturers furnish an instruction sheet with each set of rings. In the absence of the instructions, the rings can be installed by remembering a few key factors. The top compression ring is marked by a dot or a T indicating the ring should be installed with the markings pointing up. In the absence of the markings the up or downward positioning of the rings can be determined by the grooves in the rings. A groove on the inside of the ring goes in the upward position. A groove on the outside of the ring goes in a downard position. (Inside up, outside down)

The oil control ring usually has no markings and can be installed in either direction. Rings of a three piece design must be installed so that the end gaps are not in alignment.

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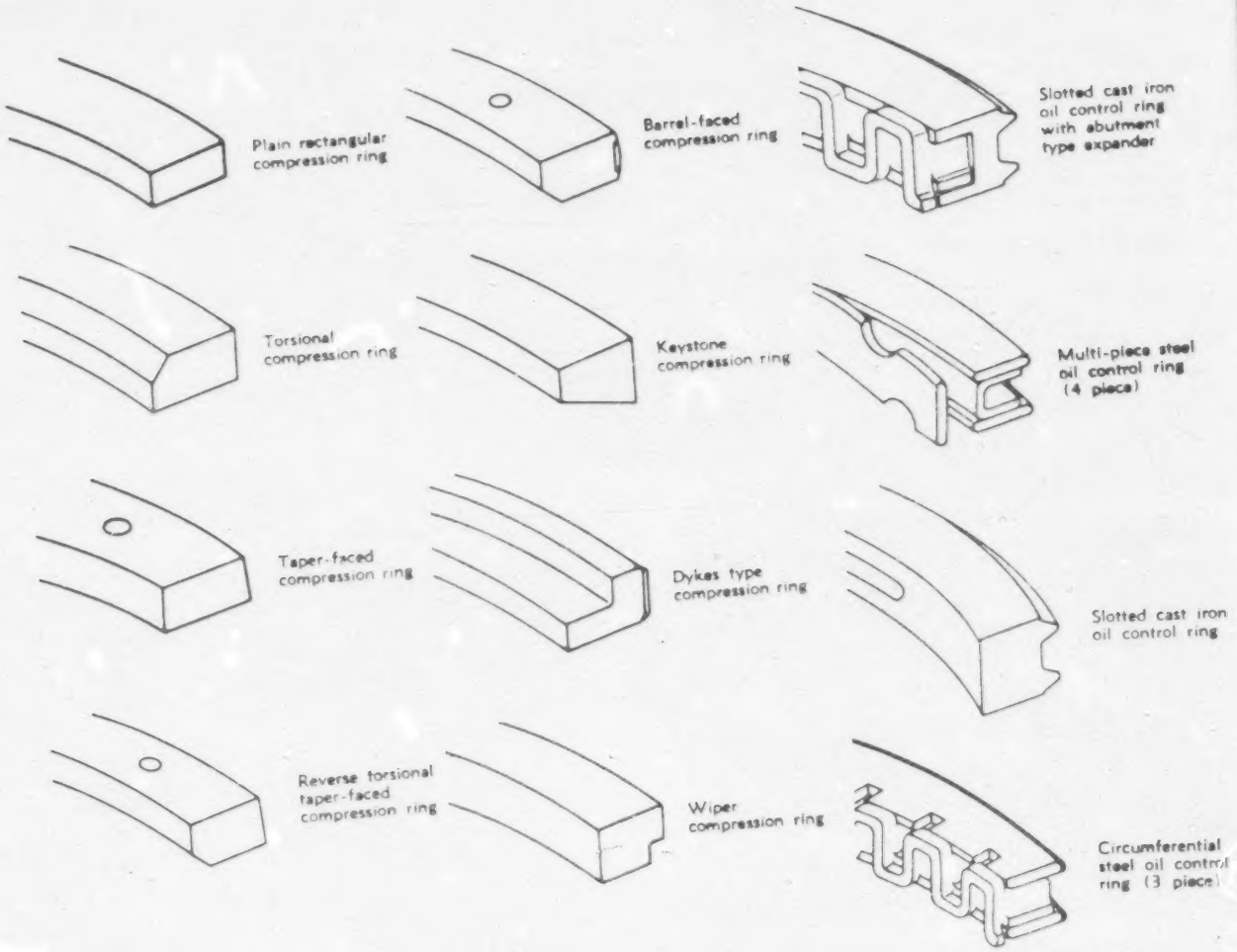
Information X continued


Plain rectangular compression ring
Barrel-faced compression ring
Slotted cast iron oil control ring with abutment type expander
Torsional compression ring
Keystone compression ring
Multi-piece steel oil control ring (4 piece)
Taper-faced compression ring
Dykes type compression ring
Slotted cast iron oil control ring
Reverse torsional taper-faced compression ring
Wiper compression ring
Circumferential steel oil control ring (3 piece)

Questions:

1. Would the outside grooves effect the pressure the ring exerts on the cylinder wall?
2. What would be the effect of inverting the piston ring?

Reference:

Billiet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 126-135).

P.C. Prescription

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AUTO ENGINES I AT 121

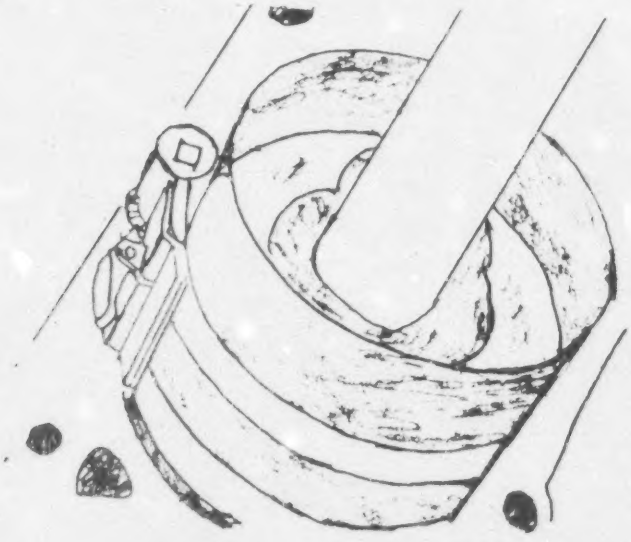
Information Y

Ring compressors

Definition: A ring compressor is used to compress rings to facilitate piston and rod assembly installation.

Essential Facts, Ideas, and Procedures

There are many types of ring compressors available. The most common one used is one that covers most piston sizes and is adjustable by tightening a band or bands around the compressor. When compressing the ring, compress the ring only enough to facilitate installation. Over tightening will only hinder piston installation. The bands on the compressor should be nearest the cylinder. When installing pistons a pushing force should be used, not a hammering action.



Questions:

1. How can one tell if a ring is broken during piston installation?
2. Is a ring compressor needed during piston removal?

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Information Z

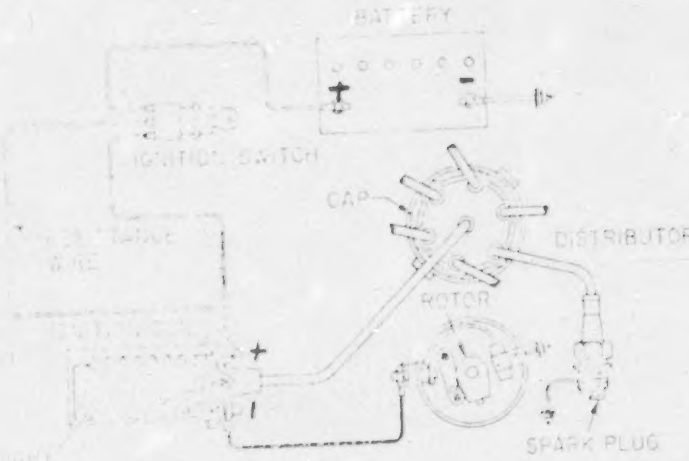
Timing engine

Definition: The proper timing of an engine will cause the occurance of a spark when the piston is at T.D.C. power stroke.

Essential Facts, Ideas, and Procedures

To correctly static time an engine after overhaul, the first step is to locate T.D.C. power stroke on number one cylinder. Install the distributor so the rotor is pointed toward the number one position on the cap. Position the distrubutor so the points just start to open in the direction of cam rotation. Place the secondary wires in sequence following the rotation of cam and the firing order of the engine.

To power time, connect the blue or green lead of timing lite to number one spark plug, connect the black lead to the negative terminal of the battery and the red lead to the positive terminal of the battery. Start the engine and align the timing marks by rotating the distributor. Adjust timing at specified engine RPM with vacuum lines removed from the distributor. (see mfg. spec.)



Questions:

1. Why is the timing set at low engine RPM?
2. Why is the timing set with vacuum lines removed?

Reference:

Hilliet, Walter E., Automotive Engines Maintenance and Repair. Chicago: American Technical Society, 1973. (pp 445-483).

Name _____

AUTO ENGINES I AT 121

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Worksheet 1

Operations 3 and 4

Measure valve stems and valve guides

Manufacturers Specifications
Valve Guides

intake _____ / _____

exhaust _____ / _____

	INTAKE			EXHAUST		
	largest measured size	out of round	taper	largest measured size	out of round	taper
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

Manufacturers Specifications
Valve Stems

intake _____ / _____

exhaust _____ / _____

	INTAKE			EXHAUST		
	largest measured size	out of round	taper	largest measured size	out of round	taper
1.						
2.						
3.						

Name _____

Worksheet 1 continued

	largest measured size	out of round	taper	largest measured size	out of round	taper
4.	_____	_____	____	_____	_____	____
5.	_____	_____	____	_____	_____	____
6.	_____	_____	____	_____	_____	____
7.	_____	_____	____	_____	_____	____
8.	_____	_____	____	_____	_____	____

Amount of warpage on head:

diagonal	lengthwise	crosswise
_____	_____	_____

Conclusion:

Parts required _____

Machining operations necessary _____

Name _____

AUTO ENGINES I AT 121

Worksheet 2

Operation 5 Test valve springs

Manufacturers Specifications

free length _____/_____

tension (compression) _____ lbs./@ _____ length

Measurements

	free length in*	free length ex*	tension in*	tension ex*	cocked in*	cocked ex*
1.	____	____	____/____	____/____	____	____
2.	____	____	____/____	____/____	____	____
3.	____	____	____/____	____/____	____	____
4.	____	____	____/____	____/____	____	____
5.	____	____	____/____	____/____	____	____
6.	____	____	____/____	____/____	____	____
7.	____	____	____/____	____/____	____	____
8.	____	____	____/____	____/____	____	____

* intake - in
exhaust - ex

Conclusion:

Parts required _____

Machining operations necessary _____

Name _____

AUTO ENGINES I AT 121

Worksheet 3

Operation 9 Measure cylinders

Manufacturers Specifications

_____/_____

	largest measured size	out of round	taper
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Does the cylinder require reboring? If so, how much?

_____

_____

Name _____

AUTO ENGINES I AT 121

Worksheet 4

Operation 10 Measure pistons

Manufacturers Specifications
Piston Diameter

piston size _____

ring grove wear _____

	largest measured size	amount of wear	ring grove wear
1.	_____	_____	1. _____
			2. _____
			3. _____
2.	_____	_____	1. _____
			2. _____
			3. _____
3.	_____	_____	1. _____
			2. _____
			3. _____
4.	_____	_____	1. _____
			2. _____
			3. _____
5.	_____	_____	1. _____
			2. _____
			3. _____
6.	_____	_____	1. _____
			2. _____
			3. _____

Name _____

Worksheet 4 continued

largest measured size	amount of wear	ring grove wear
7. _____	_____	1. _____
		2. _____
		3. _____
8. _____	_____	1. _____
		2. _____
		3. _____

Piston to cylinder clearances

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

6. _____ 7. _____ 8. _____

Manufacturers Specifications
Piston Pin and Pin Bore

(pin) _____ / _____

(pin bore) _____ / _____

clearance _____ / _____

pin diameter	bore diameter	clearance
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____

Name _____

AUTO ENGINES I AT 121

Worksheet 5

Operation 11 Inspect and measure rod

Manufacturers Specifications
Connecting Rod Pin Bore

pin bore _____ / _____

clearance _____ / _____

	largest measured size	clearance
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Manufacturers Specifications
Connecting Rod

crank pin bore _____ / _____

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

6. _____ 7. _____ 8. _____

Check for Bend and Twist of Rod

	bend	twist	double bend
1.			
2.			

Name _____

Worksheet 5 continued

	bend	twist	double bend
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____

Conclusion:

Parts required _____

Machining operations necessary _____

Name _____

AUTO ENGINES I AT 121

Worksheet 6

Operation 12 Crankshaft

Manufacturers Specifications

rods _____ / _____

mains _____ / _____

RODS

	largest measured size	amount undersized	out of round	taper
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

MAINS

	largest measured size	amount undersized	out of round	taper
1.				
2.				
3.				
4.				
5.				

Name _____

Worksheet 6 continued

	largest measured size	amount undersized	out of round	taper
6.				
7.				
8.				

Amount of run out of crankshaft

_____

Conclusion:

Parts required _____

Machining operations necessary _____

Name _____

AUTO ENGINES I AT 121

Worksheet 7

Operation 13 Camshaft

Manufacturers Specifications
Valve Lift

journals _____ / _____

intake _____ / _____

exhaust _____ / _____

JOURNALS

	largest measured size	amount undersized	taper	out of round
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

CAM LIFT

	largest measured size	amount undersized	taper	out of round
1.				
2.				
3.				
4.				

Name _____

Worksheet 7 continued

	largest measured size	amount undersized	taper	out of round
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
8.	_____	_____	_____	_____

Amount of camshaft run out

_____

Conclusion:

Parts required _____

Machining operations necessary _____

Name _____

AUTO ENGINES I AT 121

Worksheet 8

Operation 14 Main bearing clearances

Manufacturers Specifications

endplay _____/_____

mains _____/_____

main bearing clearances

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Amount of endplay of crankshaft

Name _____

AUTO ENGINES I AT 121

Worksheet 9

Operations 15 and 16

Camshaft endplay
Ring gaps

Manufacturers Specifications

camshaft endplay _____ / _____

ring gaps 1. _____ / _____

2. _____ / _____

3. _____ / _____

camshaft endplay

_____

RING GAP CLEARANCE

1)	1. _____	2)	1. _____	3)	1. _____	4)	1. _____
	2. _____		2. _____		2. _____		2. _____
	3. _____		3. _____		3. _____		3. _____
5)	1. _____	5)	1. _____	7)	1. _____	8)	1. _____
	2. _____		2. _____		2. _____		2. _____
	3. _____		3. _____		3. _____		3. _____

Name _____

AUTO ENGINES I AT 121

Worksheet 10

Operation 17 Rod bearing clearance

Manufacturers Specifications

rod bearing clearance _____ / _____

ROD BEARING CLEARANCE

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

6. _____ 7. _____ 8. _____

Name _____

AUTO ENGINES I AT 121

Worksheet 11

Operation 18 Oil pump

Manufacturers Specifications

warpage of pump cover _____/_____

side clearance _____/_____

end clearance _____/_____

tension of spring _____/_____

Actual readings:

warpage of pump cover _____/_____

side clearance _____/_____

end clearance _____/_____

tension of relief valve spring _____/_____

Name _____

AUTO ENGINES I · AT 121

Worksneet 12

Operations 20, 21, and 22 Test run engine

	Manfacturers Specifications	Actual
valve lash	_____	_____
firing order	_____	_____
location of #1 cylinder	_____	_____
ignition timing	_____	_____
idle RPM	_____	_____
water temp.	_____	_____
oil pressure	_____	_____